



NASA's Accident Precursor Analysis Process and the International Space Station

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Purpose/Agenda



Purpose:

1. *Present an overview of Precursor Analysis being implemented at NASA*
2. *Present a summary completed Precursor Pilots conducted and future plans*

Agenda:

- *Background*
 - » *Need for Precursor*
 - » *Definition of a Precursor*
- *What is Precursor Analysis?*
- *Pilot Precursor Analysis Summary*
- *Summary & Conclusion*
- *Future Work*



The Need for Precursor



- **CAIB Final Report (October 2003)**
 - Section 7.1: “*Signals of potential danger*, anomalies, and critical information should, in principle, surface in the hazard identification process and be tracked with risk assessments *supported by engineering analyses*.”
- **2006 ASAP Annual Report in regards to Safety Management**
 - “the ASAP found that ...the Agency, could better gauge the likelihood of losses by developing *leading indicators*, rather than continuing to depend on lagging indicators.”
- **NPR 8715.3C, “NASA General Safety Program Requirements” (March 2008)**
 - 2.5.2.2 System engineers shall:
 - » d. Ensure that the system safety models are developed in an iterative process to allow model expansion, model updating, and model integration as the design evolves and *operational experience* is acquired (Requirement).
 - » Note: Relevant *leading-indicator (or precursor)* events should be documented and evaluated for their impact on the system safety analyses assumptions. Trending of these precursor events should be conducted and contrasted to applicable PMs.
 - 2.5.4.1 Project managers shall ensure that the performance attributes and precursors that are identified as being *important indicators of system safety* are monitored (Requirement).



Background



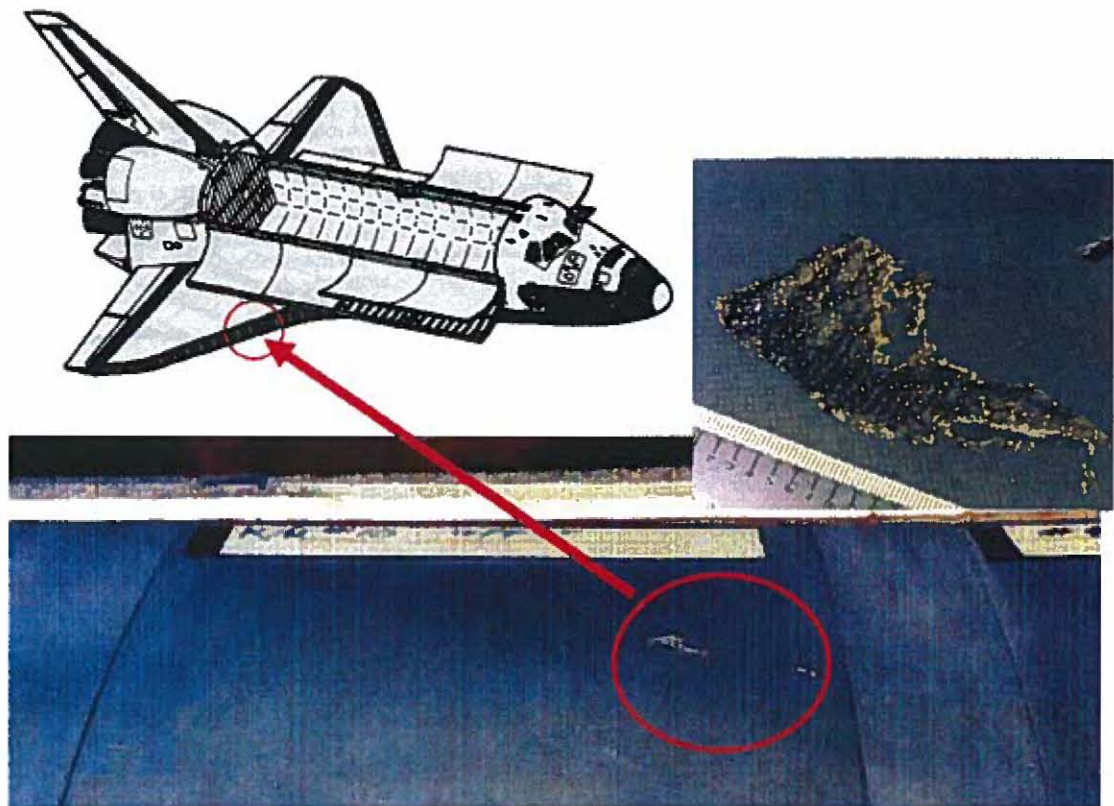
- *Definition of a “precursor”*
 - *An indication of a problem with the potential to recur with more severe consequences*
- *Key Attributes:*
 - *Observation (IFI, PRACA) indicates some “failure mechanism”*
 - *Same mechanism could occur again*
 - *The consequences could be more severe than what has been experienced*



Background



- *Columbia accident was actually preceded by a direct accident precursor, **STS-45**. Post flight inspection of the right Reinforced Carbon-Carbon leading edge found two gouges.*
- *Corrective Action Taken: Panel Replaced*
 - *This solved the immediate condition, but did not eliminate the mechanism for more dire consequences*





Operational Definition of Precursor



- *Historically, precursor analysis has been focused on failures, e.g., at Nuclear Regulatory Commission*
- *NASA process extends focus to anomalies*
 - *NASA's databases contain mostly anomalies (a defect, fault, or other deviation)*
 - *NASA has a stronger incentive to prevent any failure due to fewer barriers in its space systems*
- ***Operational definition of precursors:***
Anomalies that upon evaluation are determined to indicate a failure mechanism that may pose a significant degree of risk



Background



- ***Examples of Precursors***
 - *A near-miss because of chance or an opportune mitigation*
 - *Faults that without correction can lead to severe outcomes*
 - *Unexpected trend in test or operational data*
 - *Reduced repair/maintenance effectiveness*
 - *Unexpected effects from aging of equipment*
 - *Common causes of faults or deteriorations*



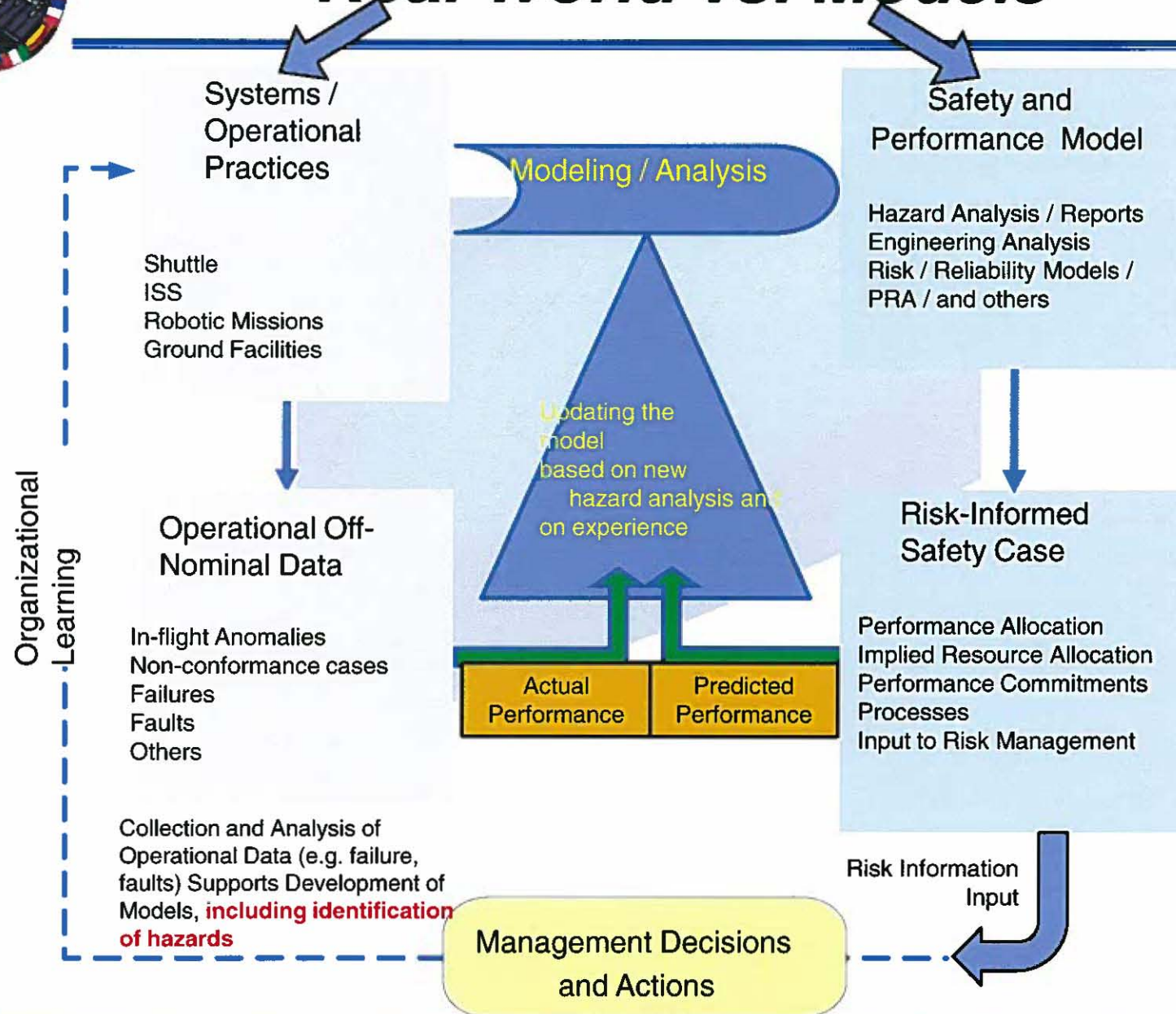
What is Precursor Analysis?



- *Evaluates IFI (In-Flight Investigation) and PRACA (Problem Reporting and Corrective Action) data to identify unrecognized accident potential or underappreciated vulnerabilities, so they can be addressed/mitigated in a timely manner*
 - *i.e. looking at your operating data, performance, and experience*
- *Precursor analysis focuses on aspects of reality that need attention by decision-makers*
 - *Conditions whose risk potential is not understood in current models (e.g., O-rings, External Tank debris, potential for vessel head to be corroded from the outside)*
 - *Performance issues whose potential is understood in principle, but whose risk-significance is not*



Real World vs. Models

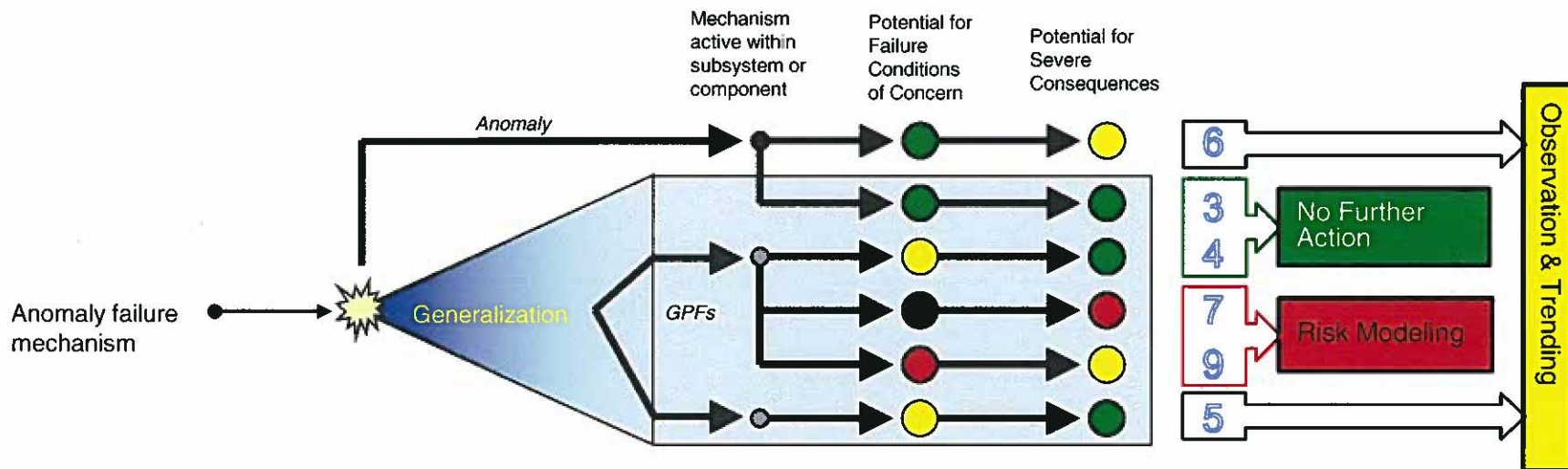




What is Precursor Analysis?



- *Precursor Analysis*
 - Screens observed anomalies for need to perform evaluation
 - Evaluates and dispositions events into three categories
 - Performs detailed analysis of selected anomalies
- *Makes risk analysis more experience-based*



• *“A failure mechanism that is benign when it occurs under one set of circumstances may not be benign under another.”*



Pilot Precursor Summaries



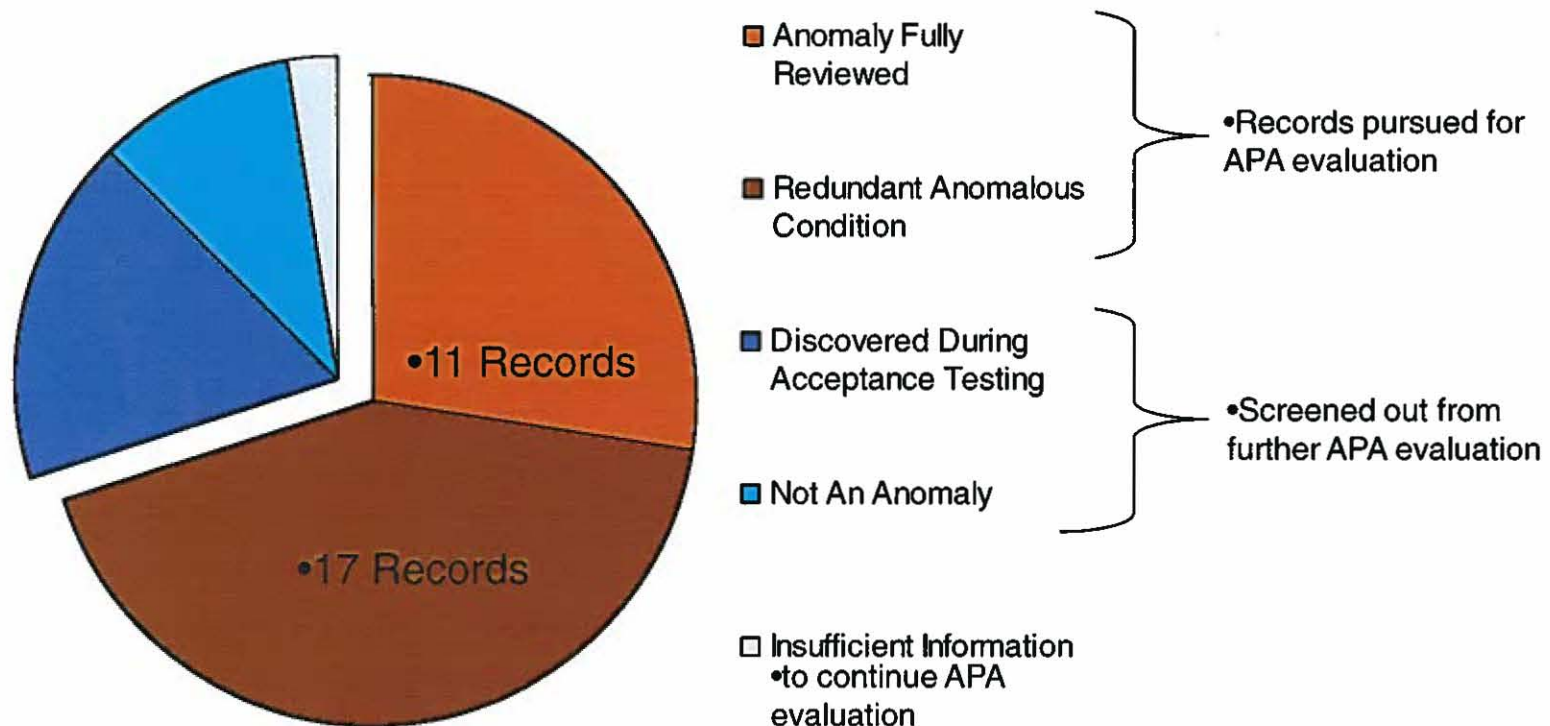
- **Objective**
 - *Exercise the Accident Precursor Analysis (APA) Process developed for the ISS*
- **Two Pilot sessions were held in 2010**
- **March 2010 - the Electrical Power System (EPS)**
- **August 2010 – Communications and Tracking (C&T) along with Command and Data Handling (C&DH)**
 - *1.5 days dedicated to anomaly review and generalization*
 - *1.5 days dedicated to grading of anomalous conditions*
 - *Constrained focus of session to the respective system anomalies and did not investigate across all ISS systems*



Anomaly Review Results



- ***A caseload of 40 EPS non-conformance records was produced for the working session and all records were reviewed***
- ***Many records, however, were screened out from further APA evaluation***

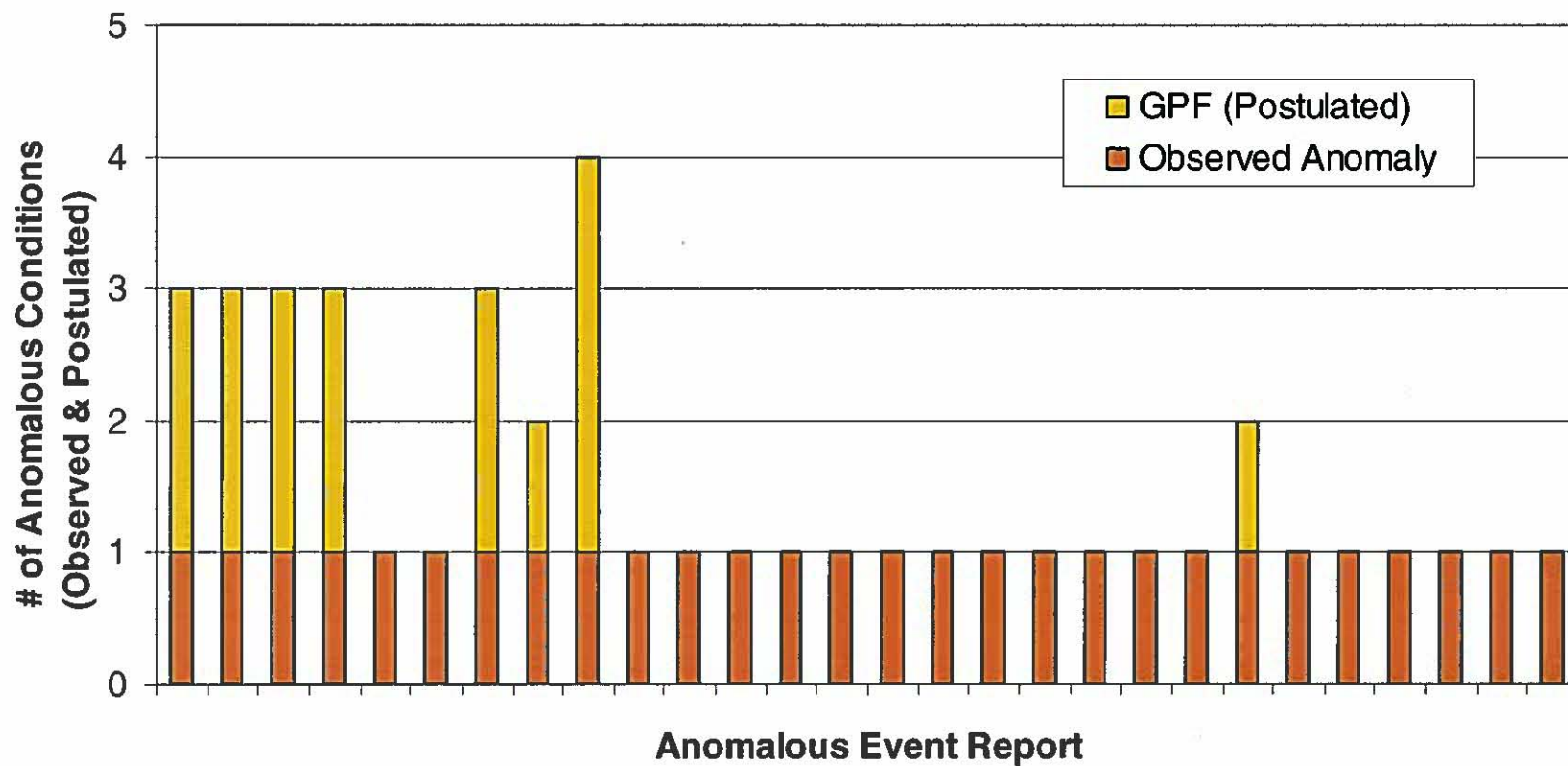




Generalization Results

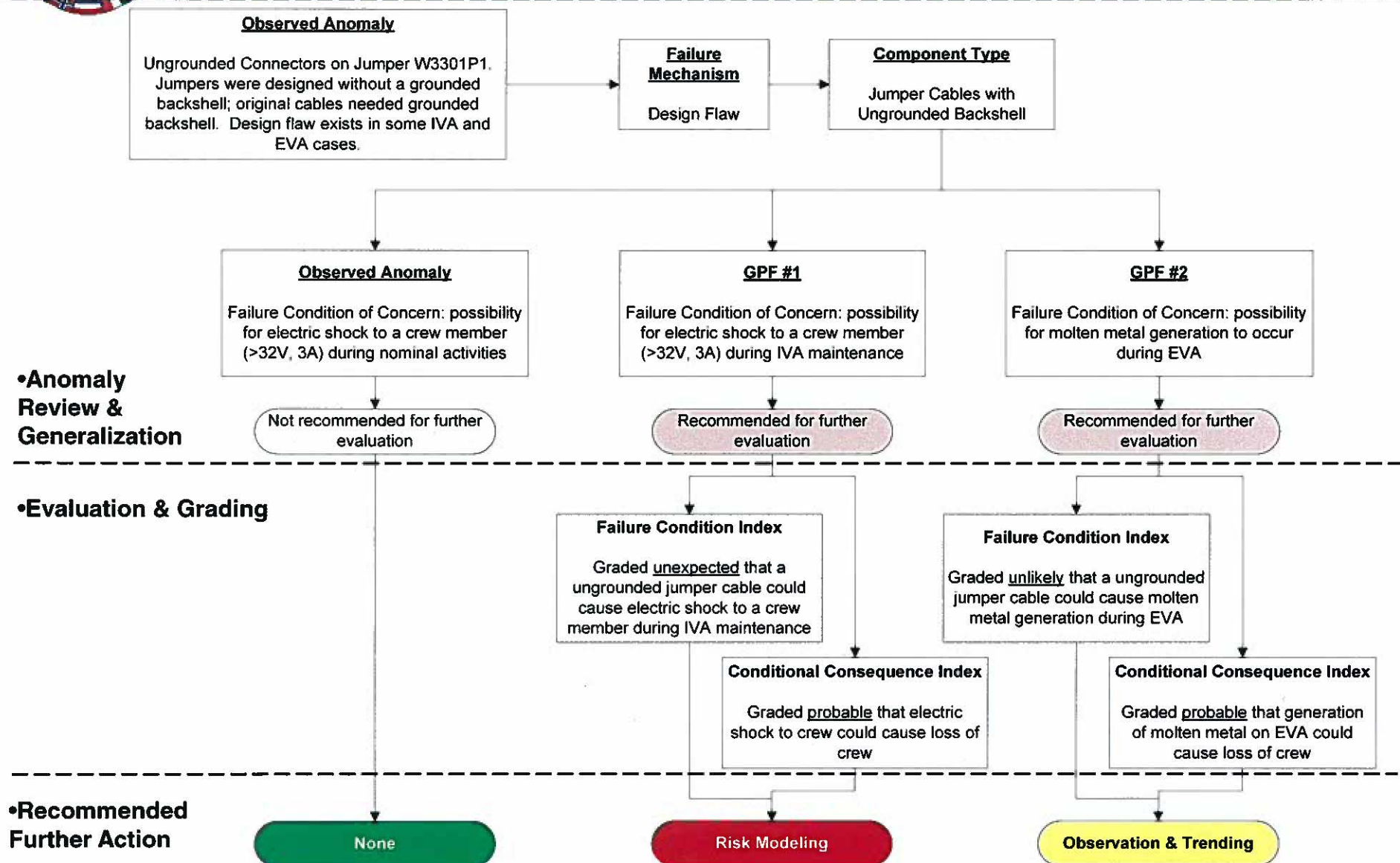


- ***Of the 28 Anomalies which were fully reviewed, 15 Generalized Potential Failures (GPFs) were created***
 - *Total of 33 anomalous conditions (both observed and postulated)*





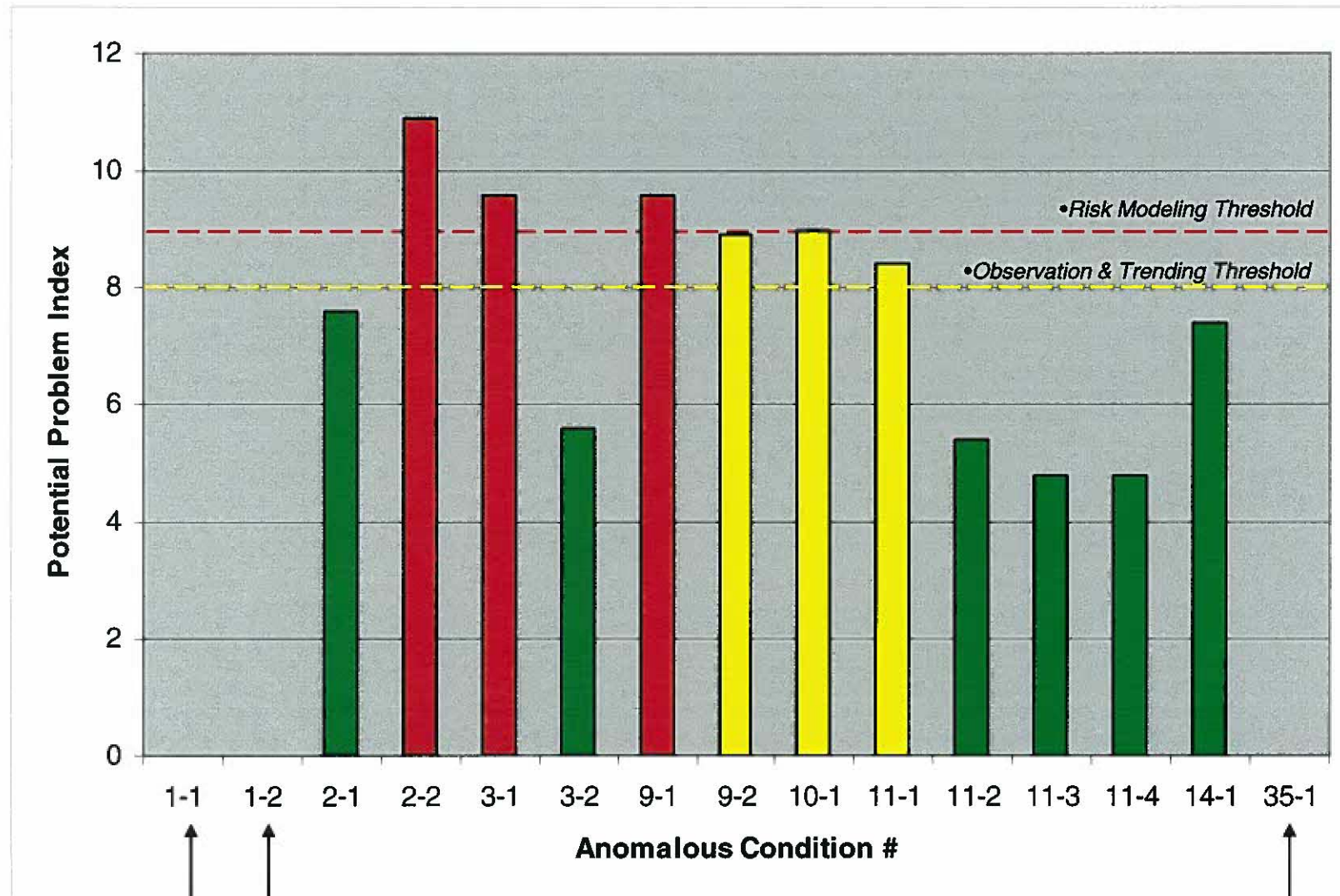
Example Walk-Through Diagram of an ISS Anomaly





Grading Results (cont)

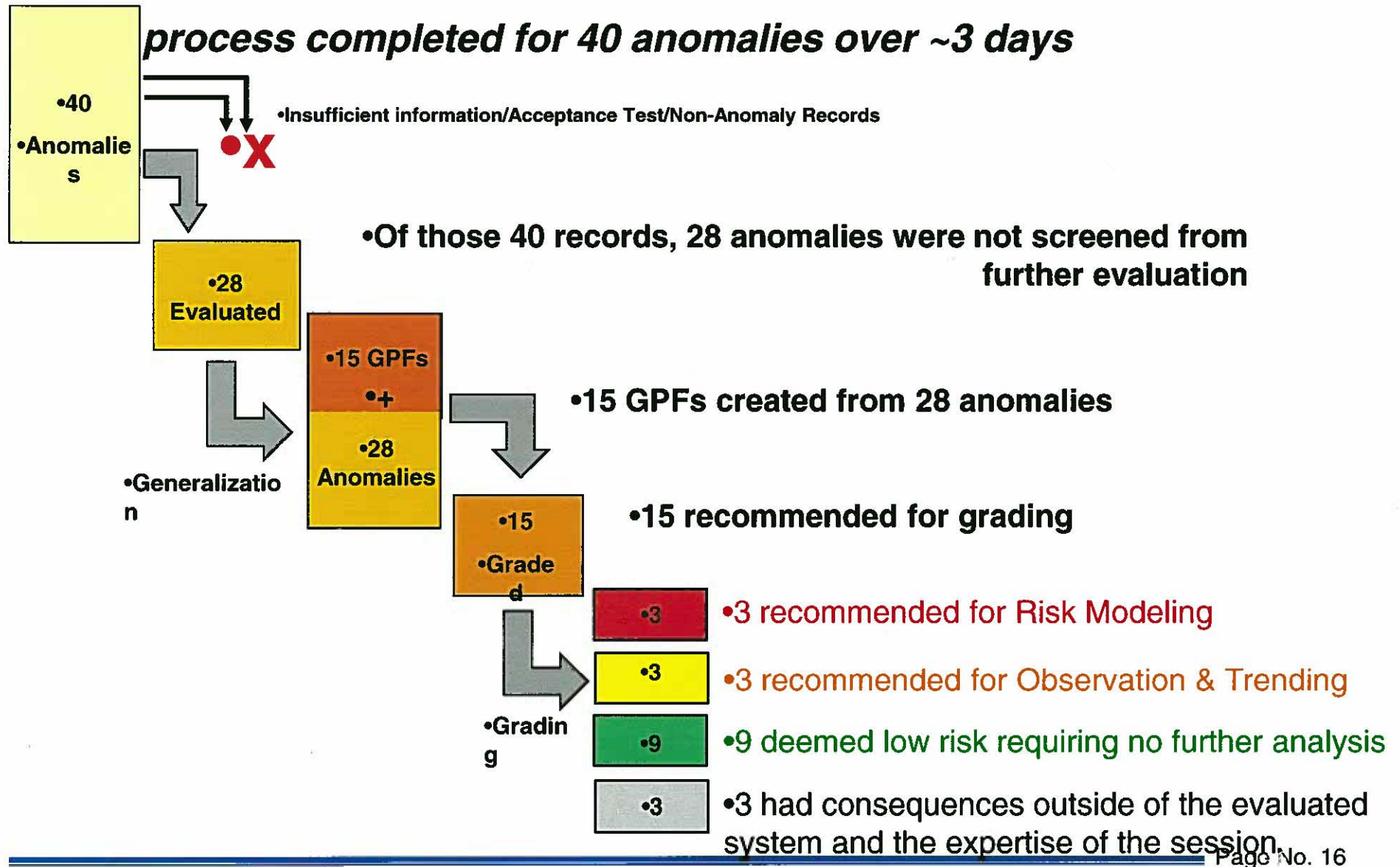
•All Anomalous Conditions Recommended for Evaluation



•Consequence Outside of EPS System & System Expertise of Session



Results Summary





Results of Screening Criteria



- **1 screen identified**
 - Screen out records recorded during acceptance testing
 - Requires search in the “detected during field” for “acceptance” or “ATP”
 - Only applies to PRACA reports
- **Other areas for potential screens did not return results**
 - Both “open” and “closed” records had sufficient information to complete generalization
 - The type of report (IFI or PRACA) did not reflect any non-applicability to the APA process
 - Records recorded both “on-orbit” as well as at NASA or contractor facilities were found sufficient to generate GPFs



Summary & Conclusion



- ***Accident Precursor Analysis (APA) has been used by other govt agencies with positive results (e.g., NRC)***
- ***Intended to be applied outside the normal problem resolution cycle***
- ***Establishes a foundation for experience-based analysis and trending of actual events from ISS, and Exploration technology demonstrators, and testing to help build more reliable and safer systems.***
- ***Timely implementation provides the possibility of completely avoiding these events***



Summary & Conclusion (cont.)



- ***Successfully demonstrated that Precursor Analysis is implementable on the ISS***
- ***Both PRACA and IFI records were evaluated, and both provided valid risk information to support the process***
- ***ISS experts noted that the Precursor exercise gave them a different perspective on the anomalies reviewed***



Future Work



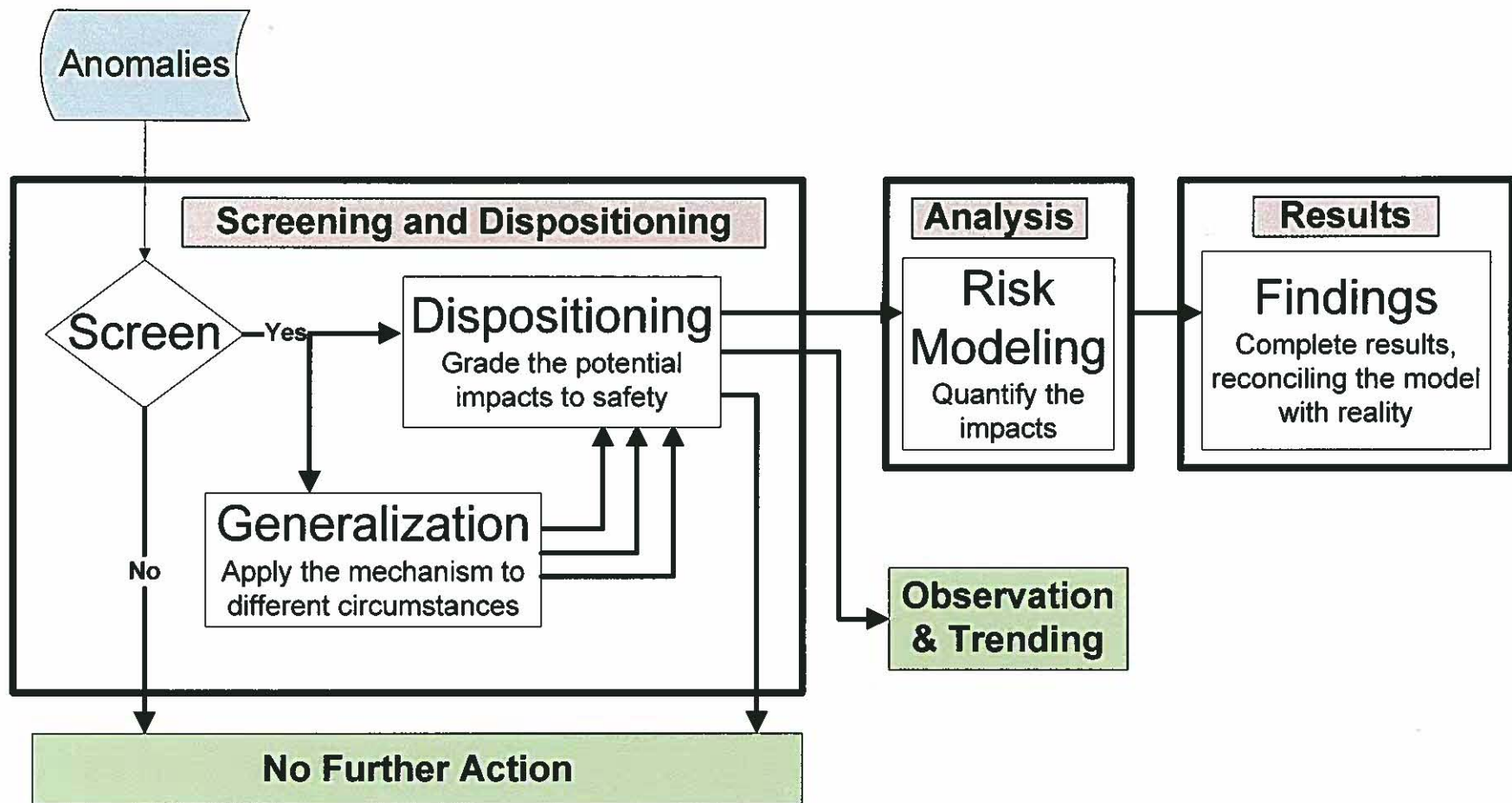
- ***Future Work***
 - *Have made the Precursor Analysis part of the Fiscal Year 2011 baseline work plan*



Back-up

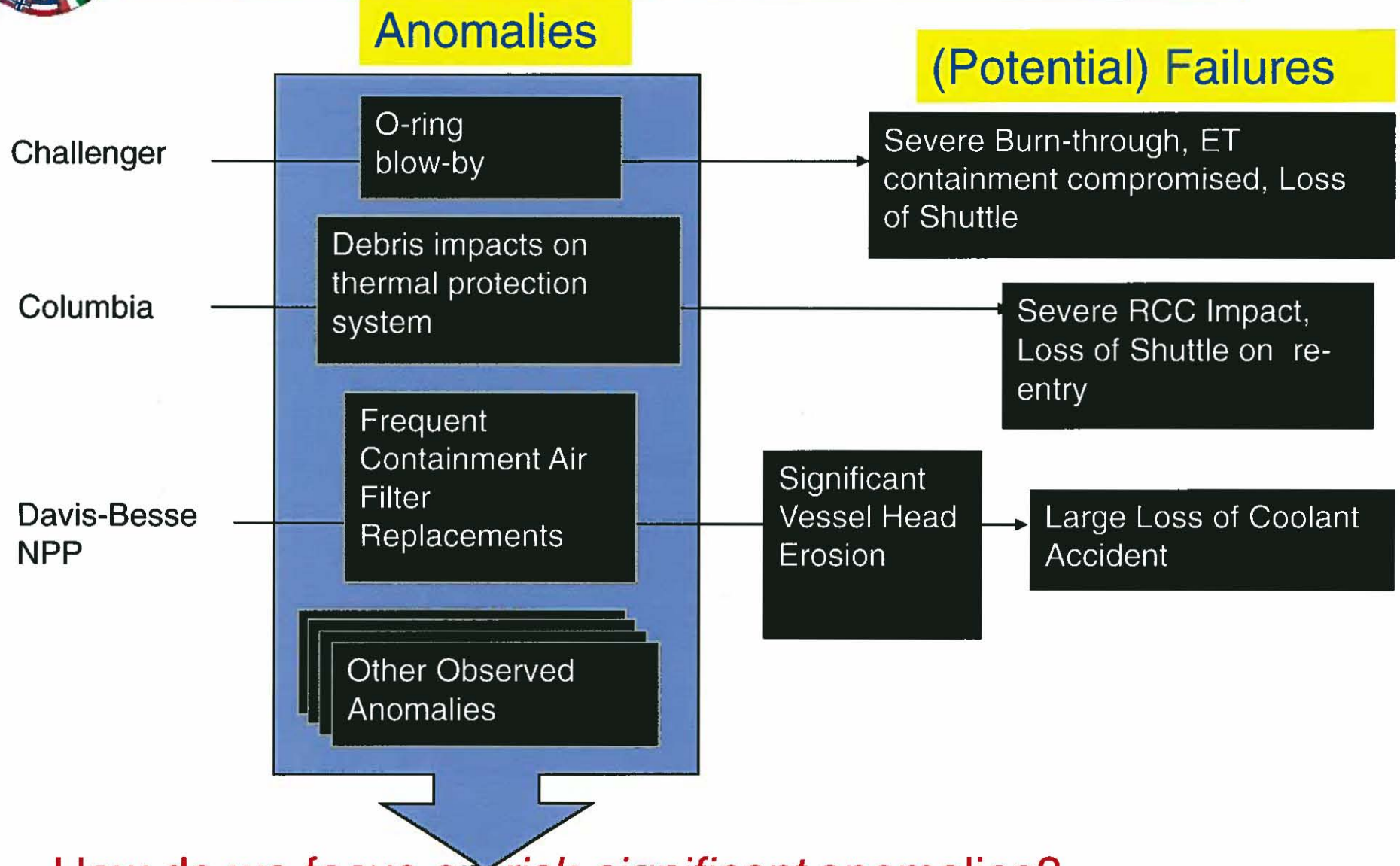


NASA APA Process





Well-Known Precursors



How do we focus on *risk-significant* anomalies?